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TCP WELCOME
TCP variant for Wireless Environment, Link losses, and COngestion packet loss ModEls

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- **PLAN**

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    b. **Loss Recovery Algorithm**
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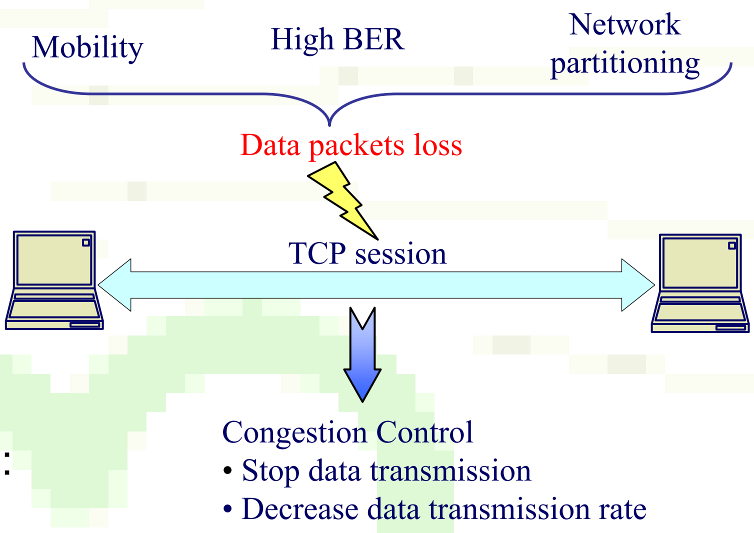
- **Motivation**
  - TCP does not recognize the cause of data packet losses
    - TCP reacts, always, as it is due to congestion
  - Within wireless ad hoc networks, losses:
    - Congestion
    - Link failures (mobility, battery depletion)
    - Wireless channel errors (interference, signal loss)
  - TCP for wireless ad hoc networks:
    - Classification of data packet loss causes: Loss Differentiation Algorithm
    - Appropriate Loss Recovery Algorithm



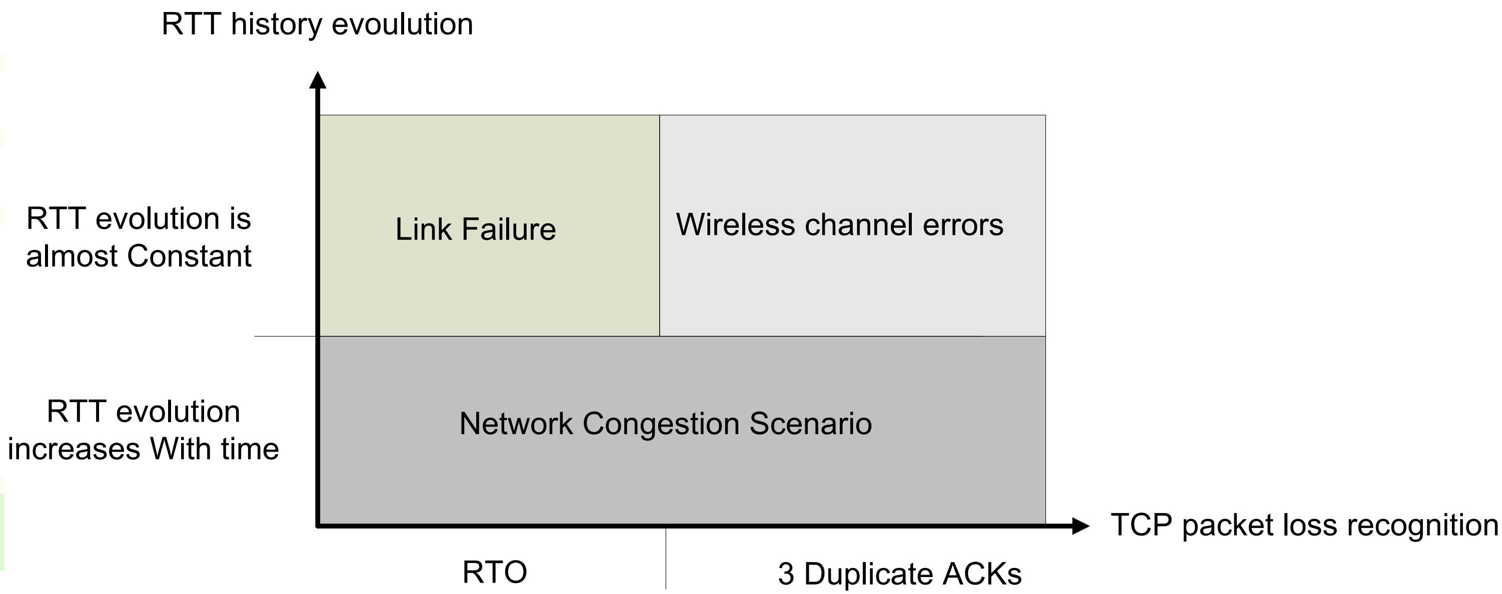
- **Related Work**
  - Loss differentiation and classification algorithms can be categorized into two classes according to their characteristics implicit and explicit
  - Implicit loss classification mechanisms
    - TCP Westwood (sender-side modification of TCP New Reno)
      - Estimates the connection bandwidth based on the rate of the received acknowledgements
      - Uses the estimated bandwidth to adjust and set its congestion window and slow-start threshold parameters
      - Unable to handle link losses situations where burst packet losses occur and an ad hoc re-routing is required
  - Explicit loss classification mechanisms
    - Physical and link-layer solutions : forward error correction (FEC) and/or link level retransmissions
    - Non-Congestion Packet Loss Detection (NCPLD) algorithm
    - Spike Scheme
    - ZigZag Scheme
      - All these approaches suffer from the same limitation when used in MANETs: they are not designed to cope with the losses due to link losses and ad hoc route breaking
      - Most approaches assumes that only the last hop is the wireless link; which is not the case within wireless ad hoc networks (all the links are wireless)

- **TCP-WELCOME**
  - Implicit loss differentiation mechanism:
    - Loss Differentiation Algorithm
    - Loss Recovery Algorithm
  - Differentiate between:
    - Wireless channel errors
    - Link failure within the network
    - Network congestion
  - Based on RTT measures at the sender side host
    - No support needed from any intermediatory nodes and from the corresponding nodes
    - No clock synchronization needed at both sending and receiving ends

- **TCP-WELCOME:Loss Differentiation Algorithm**

  - The history of RTT samples evolution over the connection
  - The data packet loss triggers (3 Duplicate Acknowledgments, or Retransmission Time Out - RTO)
  - Classifying Wireless Channel related Losses
    - RTT samples evolution within the network is not highly fluctuating and stays around an average value and the data packet loss is recognized through three duplicate acknowledgements
  - Classifying Link Failure related Losses
    - RTT samples evolution is relatively constant, and TCP recognizes data packet loss through RTO expiration

- Classifying Network Congestion related Losses
  - RTT samples at the sender side is increasing gradually regardless of data packet loss recognition by TCP (RTO or 3 Duplicate



TCP-WELCOME : Loss Recovery Algorithm

- Link failure
  - $RTO_{new} = (RTT_{new} / RTT_{old})\ RTO_{old}$
  - $CWND_{new} = (RTT_{old} / RTT_{new})\ CWND_{old}$
- Wireless related errors (interference)
  - No CWND or RTO re-computation or adjustements
- Congestion
  - TCP New Reno behaviour

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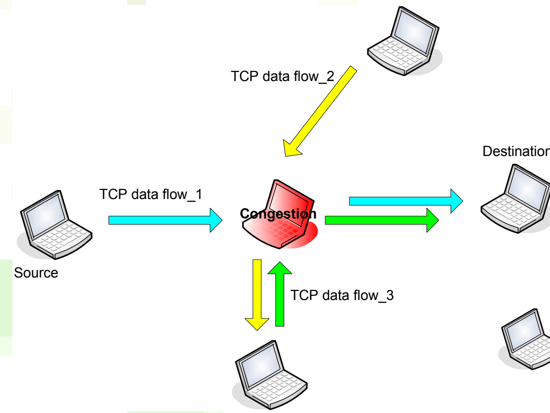
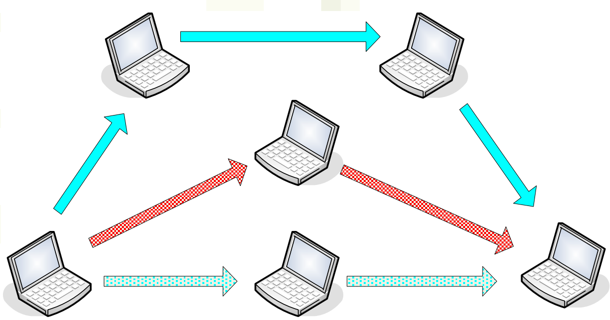
- **TCP-WELCOME Validation**
  - Study the effect of the different loss scenarios (link failure, congestion, signal loss, or interference)
  - Evaluation of TCP WELCOME and comparisons with other TCP variants such as New-Reno, SACK, Vegas, and Westwood
  - Use of Ad-hoc On-demand Distance Vector (AODV) as an ad hoc routing protocol
  - NS2 as a network simulation tool
  - Nodes communicate through identical wireless radio settings using the standard MAC 802.11 having a bandwidth of 2Mbps and a radio propagation range of 250 meters

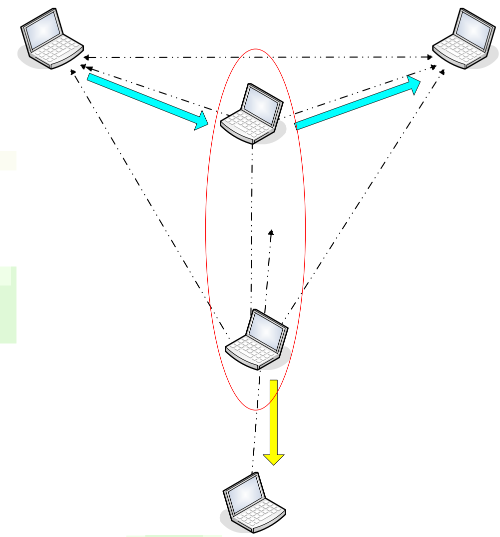
- **Validation Scenarios**

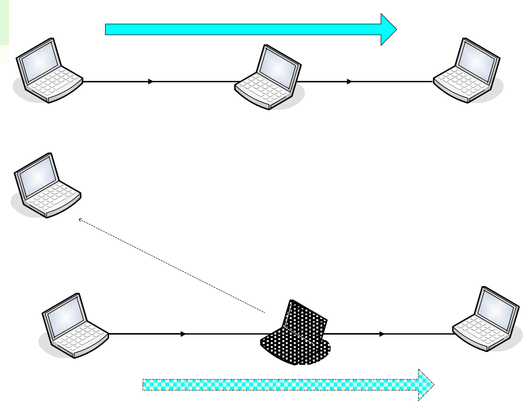


Congestion



Link Failure





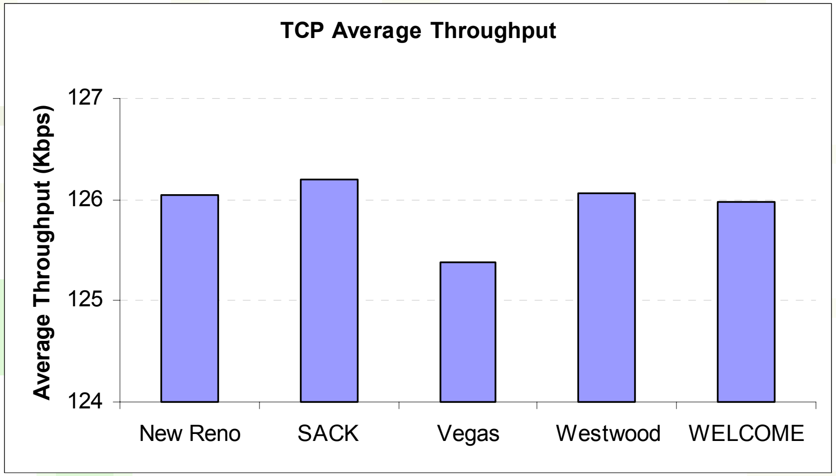
Interference

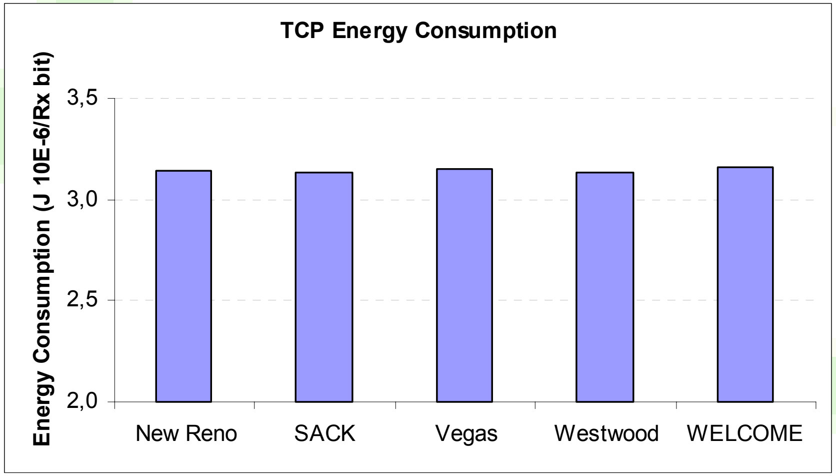
Signal Loss

- **TCP-WELCOME Validation Results : Congestion**

- **Throughput:**
  - TCP-WELCOME has a similar performance compared to best performing variants (New-Reno, SACK, and Westwood)

- **Energy Consumption:**
  - TCP-WELCOME has the same performance as the other studied variants
    - TCP-WELCOME reacts in the same manner in front of congestion (as in TCP New Reno)
  - TCP-WELCOME is able to classify correctly packet losses due to network congestions and take the right actions to recover from the loss



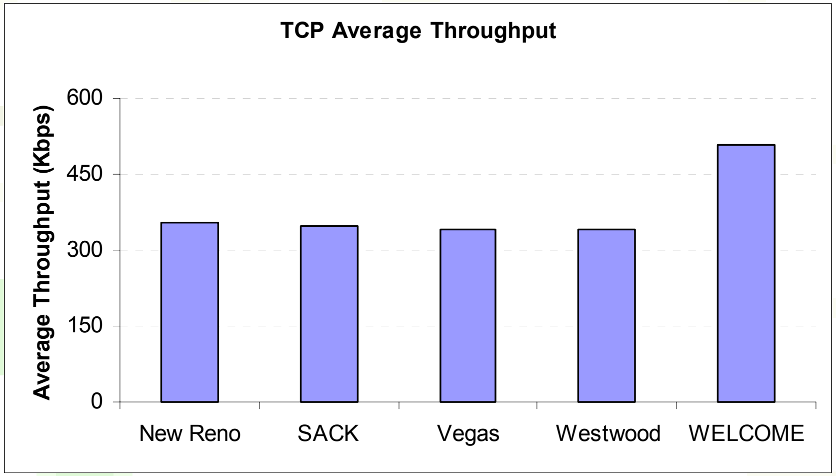


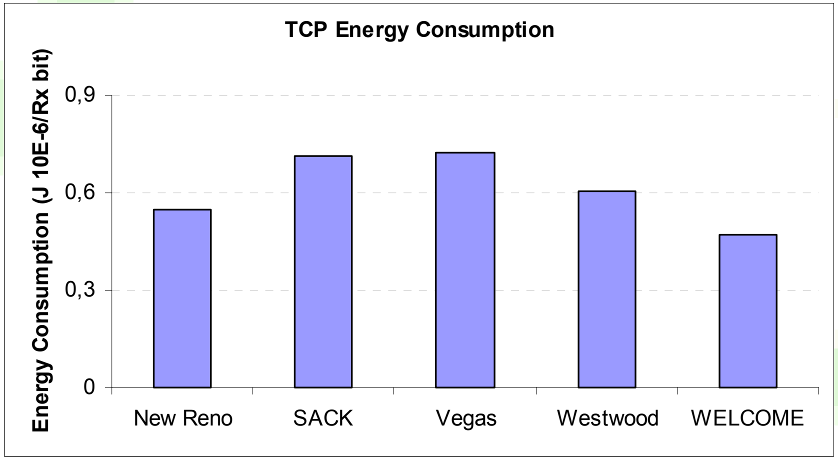
- **TCP-WELCOME Validation Results : Interference**

- **Throughput:**
  - TCP-WELCOME outperforms all the other variants

- **Energy Consumption:**
  - TCP-WELCOME outperforms all the other variants

- **Its performance improved compared to other TCP variants:**
  - The ability of TCP-WELCOME to classify the cause of data loss, as due to wireless channel imperfections
  - Not decreasing the data transmission rate as in all other TCP Variants (including TCP-Westwood)

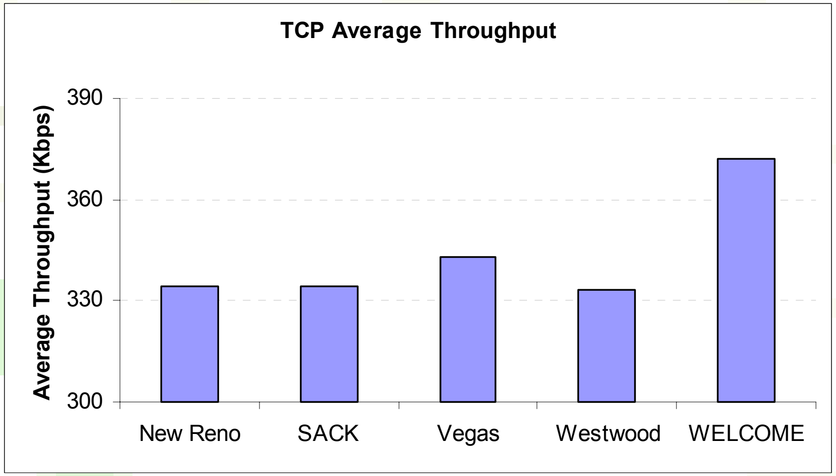


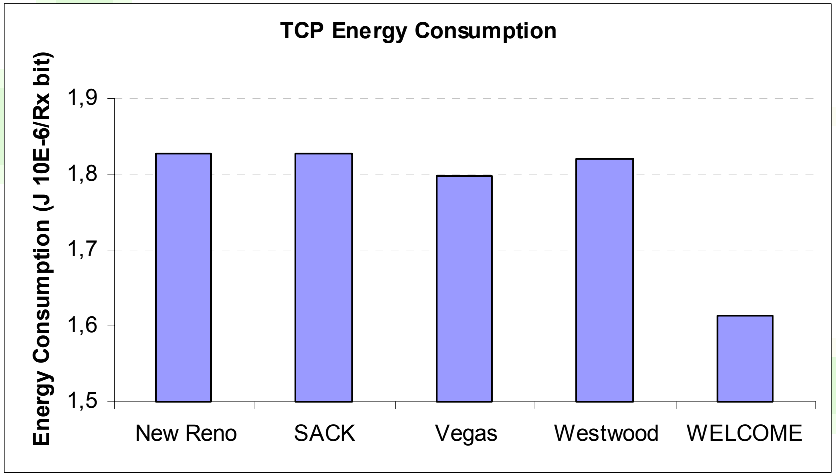


- **TCP-WELCOME Validation Results : Link Failure**

- **Throughput:**
  - TCP-WELCOME is the best performing variant
    - The ability of TCP-WELCOME to detect that the packet losses are due to link failure and to react appropriately

- **Energy Consumption:**
  - TCP-WELCOME has the lowest energy consumption
  - Adjusting data transmission rate according to the new discovered route's characteristics helps conserving node's energy and maximizing the average throughput





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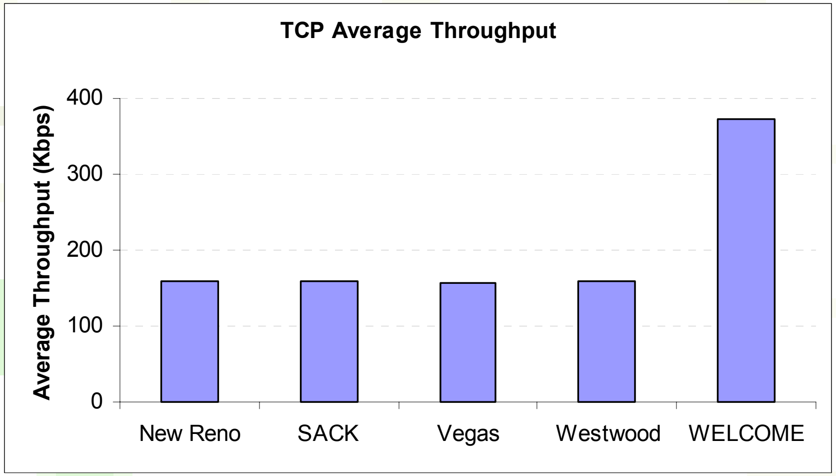
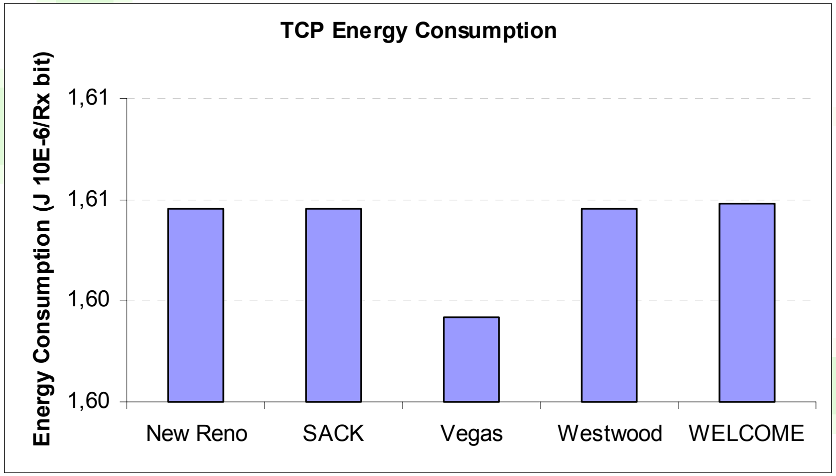
- **TCP-WELCOME Validation Results: Signal Loss**

- **Throughput:**
  - TCP-WELCOME outperforms the others in term of average throughput
  - TCP-WELCOME does not decrease its data transmission rate after data packet loss (as in TCP New Reno)
    - noticed throughput gain and better usage of wireless channel bandwidth resources

- **Energy Consumption:**
  - Energy consumption of most variants is almost the same
  - TCP Vegas has the least energy consumption among the others; its performance in term of average throughput is bad





- **Conclusions and Future Work**

- **Conclusions:**
  - we proposed TCP-WELCOME, a new TCP variant that is suitable for mobile ad hoc networks.
  - TCP-WELCOME uses a Loss Differentiation Algorithm (LDA) that recognizes efficiently the three common packet loss causes within such networks: network congestion, wireless channel errors, and link losses.
  - we showed the performance improvement of TCP-WELCOME by comparing it to different TCP variants under different data packet loss scenarios (congestion, interference, link failure, and signal loss).
  - TCP average throughput and energy consumption are improved significantly using TCP-WELCOME.
    - Its ability to clearly classify data packet loss and take the most appropriate actions to recover from packet losses (Loss Recovery Algorithm).

- **Fututre Work:**
  - study the performance of TCP-WELCOME and improve its behavior according to the different ad hoc routing protocols (i.e. reactive or proactive).
  - study the effect of these routing protocol algorithms on TCP-WELCOME performance.
  - Analyze the performance of TCP-WELCOME using more complex and mixed scenarios.